GRASSLANDS AS COMPARED TO ADJACENT *QUERCUS GARRYANA* WOODLAND UNDERSTORIES EXPOSED TO DIFFERENT GRAZING REGIMES

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ABSTRACT

The grasslands in northwestern California show striking differences in species composition when compared to understories of adjacent woodlands. In addition, sites that differ in the length of time during which cattle graze are distinct. Native grasses, although present, are not important in any of the areas studied. Greater perennial grass cover occurs only in the grassland grazed for a partial season. Perennial forbs are well represented in the sites grazed for a partial season. A greater cover of introduced annual grasses and reduced species richness are found in sites grazed for a full season.

Many of the extensive woodlands in California support grassy ground layers. These understories are similar structurally to adjacent grasslands lacking trees, but the two differ in species composition. This difference has been referred to as "the canopy effect," and has been shown to occur under *Quercus douglasii* (Holland 1973) and *Q. agrifolia* (Parker and Muller 1982). We are interested in whether a similar effect occurs under *Q. garryana* in the northwestern part of the state. We are interested further in whether grazing practices also result in changes in species composition. Some of these woodlands are grazed by cattle for about four months, only late in the season after a toxic larkspur, *Delphinium trolliifolium,* has died back for the year (Rehling 1979). These sites will be referred to as being grazed for a partial season. Areas lacking larkspur are grazed for as much of the year as weather permits, typically about eight months. These sites will be referred to as being grazed for a full season.

Location. Woodlands and grasslands form an extensive mosaic in northwestern California. The woodlands represent the Bald Hill phase of the northern woodland (Griffin 1977); the grasslands are described by Heady et al. (1977) as coastal prairie. Two sites based on the length of grazing season were chosen in an area near Schoolhouse Peak, Humboldt County, California. One, grazed for a partial season, was located in Redwood National Park; the other, grazed for a full season, was on adjacent private land. Each site had both a woodland and a grassland component. The areas were chosen to minimize variation in soils, slope, and aspect. The average elevation was 850 m.

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Methods

Quercus garryana was the only canopy tree in the woodlands chosen for study. Sampling was limited to the herbaceous layer, and was done in early May and again in late June 1982. The area was divided into four homogeneous vegetation units: 1) grassland grazed for a partial season, 2) woodland grazed for a partial season, 3) grassland grazed for a full season, and 4) woodland grazed for a full season. Transitional areas, obvious springs, and drainage courses were not sampled. Woodland was distinguished from grassland by woodland having oak canopy overhead. Areas outside the canopy of oaks were designated as grassland.

After testing three plot sizes, a 0.125 m^2 circular plot was chosen as most efficient (Cochran 1977). Ten 10 m transects were located randomly within each vegetation unit. After locating the transects, five plots were sampled randomly along each transect. Advance estimates of means and variances for the species with the largest cover value in each unit were obtained from the early data. They were used to judge sampling adequacy. A sample size of 50 plots per vegetation unit produced the desired $<10\%$ standard error.

The percentages of ground covered by live plants, thatch, and bare ground were estimated and recorded for each plot. These estimates were made using the Domin scale (Mueller-Dombois and Ellenberg 1974). Absolute and relative cover were calculated by first transforming Domin scale intervals to midpoint values. These values were then multiplied by the number of plots in which a species occurred to calculate the absolute cover of a species. Relative cover values for each species were then expressed as percentages of this total. The sum of all species values represents ground covered by live plants. Thatch and bare ground were calculated in the same manner. Thatch was considered to be any dead organic material above the surface of the ground. Thatch cover was estimated regardless of overlying live plants.

Results

Considering only the June data, important species in the grasslands have lower cover or are absent from under the oaks. Similarly, species typical of woodland understories vary markedly in cover or are absent from the grasslands (Table 1). The average number of species per plot in the areas grazed for a partial season is significantly greater than the number in the areas grazed for a full season ($\bar{x}$ per plot: 10 vs. 8; t-test, Sokal and Rohlf 1969). The number of exclusive species is greatest in the woodlands grazed for a full season. Similar patterns are seen in the May data (Saenz 1983).

Only in the grassland grazed for a partial season are perennial grasses common (Table 2). In the other sites, both woodlands and

TABLE 1. SPECIES COVER CALCULATED RELATIVE TO THE COVER OF ALL LIVING PLANTS (TABLE 2) USING JUNE 1983 DATA. Species organized by life form and place of origin. Introduced plants indicated by an asterisk (*), others are considered native to the area. Nomenclature follows Kartesz and Kartesz (1980).

	Grasslands		Woodlands	
Site grazed a partial season	XXXXX		XXXXX	
Site grazed a full season		XXXXX		XXXXX
Perennial grasses and sedges				
*Agrostis stolonifera**	11.3	—	1.3	2.1
*Arrhenatherum elatius**	10.7	—	0.2	—
Bromus orcuttianus	—	—	1.0	0.4
Carex tumicola	9.3	—	<0.1	—
*Dactylis glomerata**	1.1	—	6.9	—
Elymus glaucus	1.7	0.3	0.2	2.1
Festuca viridula	11.8	—	1.6	—
*Holcus lanatus**	1.7	0.1	0.5	0.7
*Lolium perenne**	0.2	—	0.8	—
Luzula multiflora	0.3	—	3.3	0.4
Melica subulata	0.1	—	0.1	0.2
Poa canbyi	—	0.1	—	3.0
*Poa pratensis**	7.2	—	1.0	0.3
Annual grasses				
*Aira caryophyllea**	1.0	4.2	—	0.6
*Avena barbata**	—	1.3	—	0.2
Bromus carinatus	<0.1	—	—	0.2
*Bromus diandrus**	—	0.5	—	0.1
*Bromus hordeaceus**	5.7	6.2	0.1	0.4
*Bromus sterilis**	<0.1	—	14.5	0.5
*Cynosurus echinatus**	5.4	41.9	16.4	64.6
*Taeniatherum caput-medusae**	—	3.0	—	—
*Vulpia bromoides**	0.2	1.1	—	0.4
Perennial forbs				
Achillea millefolium	3.0	—	1.0	0.5
Agoseris grandiflora	—	0.1	—	0.2
*Bellis perennis**	2.6	3.0	0.2	0.2
Cardamine californica	1.1	—	1.4	—
Delphinium trolliifolium	1.6	—	9.0	—
Dichelostemma pulchellum	1.2	—	0.2	0.3
Fragaria vesca	—	—	1.8	—
Galium mexicanum	<0.1	0.1	4.1	1.3
*Hypochoeris radicata**	<0.1	1.4	0.2	—
Lithophragma affine	—	—	0.1	—
Marah oreganus	<0.1	—	—	—
Osmorhiza chilensis	—	—	8.2	1.3
*Plantago lanceolata**	5.3	—	0.2	—
Pteridium aquilinum	0.3	0.9	—	—
Ranunculus occidentalis	0.6	0.3	1.3	6.7
*Rumex acetosella**	6.0	13.1	6.4	3.7
Sanicula crassicaulis	—	—	3.0	2.1
*Taraxacum officinale**	0.8	0.3	<0.1	0.2
*Trifolium repens**	—	—	<0.1	—
*Vicia benghalensis**	0.4	0.4	1.2	2.5
Viola praemosa	4.0	—	—	—

TABLE 1. CONTINUED.

	Grasslands		Woodlands	
Site grazed a partial season	XXXXX		XXXXX	
Site grazed a full season		XXXXX		XXXXX
	Annual forbs			
Cardamine oligosperma	—	—	0.3	—
*Cerastium glomerata**	0.3	0.1	—	—
Claytonia perfoliata	0.1	—	5.6	1.6
Epilobium minutum	1.5	3.8	0.1	0.1
*Erodium cicutarium**	—	0.6	0.2	—
*Linum bienne**	—	—	—	0.5
Lotus subpinnatus	0.7	7.1	0.2	1.4
Lupinus bicolor	—	0.1	—	—
Madia gracilis	0.5	6.2	—	—
Micropus californicus	—	0.4	—	—
Microseris gracilis	—	0.6	—	—
Microsteris gracilis	—	—	<0.1	0.5
Nemophila parviflora	—	—	2.9	—
Plectritis congesta	—	—	—	1.3
*Sherardia arvensis**	1.3	0.9	—	—
*Stellaria media**	—	—	2.0	0.3
*Torilis arvensis**	1.0	1.1	2.5	0.2
Trifolium albopurpureum	—	0.7	—	0.5
Trifolium tridentatum	—	—	—	0.2

the grassland grazed for a full season, the cover by annual grasses is significantly greater than that of the perennial grasslands (t-test). *Cynosurus echinatus* is the major annual at these sites (Table 1).

Introduced grasses contribute more to the flora than do the perennial ones, and they have more cover (Table 2). These differences are significant (t-test) in all but the grassland grazed for a partial season.

As with the grasses, forb species tend to be perennial, but unlike the grasses they tend to be native (Table 2). The cover of perennial and annual forbs varies more among the sites than it does for the grasses. Forb cover differences are not significant. Introduced forb cover in the grasslands is similar to that of the native forbs. In the woodlands, native forb cover is greater than that of introduced forbs.

Thatch covers much of the ground (Table 2). The areas grazed for a full season have more thatch than those grazed for a partial season. The differences in thatch between the two woodlands is insignificant, but the differences between the grasslands is significant (t-test). Most thatch, especially in areas grazed for a full season, is dead *Cynosurus echinatus*.

More bare ground exists in areas grazed for a full season than in areas grazed for a partial season. Additionally, there is more bare ground under woodland canopies than in the grasslands. These differences are significant (Table 2).

TABLE 2. SUMMARY OF FLORISTIC AND STRUCTURAL CHARACTERISTICS ORGANIZED BY VEGETATION TYPES AND GRAZING REGIMES.

	Grasslands		Woodlands	
Grazed a partial season	XXXXX		XXXXX	
Grazed a full season		XXXXX		XXXXX
No. species sampled	39	30	42	37
Mean species/plot	10.7	8.0	10.0	8.0
Number of grass and sedge species				
Perennial species	11	3	12	8
Annual species	6	7	3	8
Native species	6	2	6	6
Introduced species	10	8	9	10
Number of forb species				
Perennial species	15	9	17	11
Annual species	7	11	9	10
Native species	4	8	6	7
Introduced species	3	4	3	3
Relative cover of species (%)				
Perennial grasses	55.4	0.5	16.9	9.1
Annual grasses	12.3	58.2	31.0	66.0
Native grasses	23.2	0.4	6.1	6.1
Introduced grasses	44.5	58.4	41.5	68.9
Perennial forbs	26.9	19.6	38.3	18.3
Annual forbs	5.4	21.7	13.8	6.6
Native forbs	14.6	20.3	37.1	17.5
Introduced forbs	17.7	20.9	15.3	7.5
Ground covered by living plants	41.6	14.5	34.6	20.7
Ground covered by thatch	56.4	79.6	61.6	71.9
Bare ground	2.0	5.9	3.8	7.4

DISCUSSION

Dissimilarities found in the species composition of grasslands and woodlands in northern California are consistent with the canopy effect hypothesis. Certain species are restricted to grasslands, others to woodlands; those found in both vegetation types vary in importance. These differences suggest that the environment found under the *Quercus garryana* canopy is unlike that of the surrounding grassland. The presence or absence of a canopy is constant between the vegetation units, so differences between the grazing regimes can be sought in Tables 1 and 2. It is evident that perennial grass and forb cover is greater in areas grazed for a partial season as compared to areas grazed for a full season. We hypothesize that cropping of leaves over an extended period depletes the storage capacity of the plants, and can result in loss of perennials from the vegetation. After years

of season-long grazing, seeds of annuals can become established in areas left by the declining populations of perennial plants.

In a region where perennial grasses dominated the grassland and woodland understories historically (Heady et al. 1977), annual grasses are now more important than perennial grasses in all but the grassland grazed for a partial season. If grazing favors annuals it is expected that the areas grazed for a full season would be dominated by annual grasses. In addition, if cattle prefer woodlands, then the grasslands may receive less grazing over the year. Such differential grazing may explain the perennial grass abundance in the grassland grazed for a partial season, but it does not explain the annual grass dominance in the woodland grazed in the same way. In other woodland studies, researchers have noted that the herbaceous cover consists of mainly annual grass species, even without grazing (Davy 1902, Duncan and Clawson 1979). According to local ranchers, however, cattle stay under the oak canopy at the study site for a greater portion of the season than in the open grassland.

In areas grazed for a full season, the number of plant species is lower than in areas grazed for a partial season. Grazing appears in this case to lower species richness by reducing the number of kinds of perennials. Surprisingly, the amount of thatch is greater in areas grazed for a full season. Apparently, cattle graze preferentially on plants other than the annual *Cynosurus*. Heady (1956) has pointed out that accumulation of thatch not only reduces seed sites, but smothers living plants and even reduces seed stalk formation. The lower species richness and plant cover in the areas grazed for a full season suggest that thatch is inhibiting the annuals as well. The smothering by thatch, combined with the selective grazing by cattle and response of the plants, favors annuals in sites grazed for a full season.

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ANNOUNCEMENT

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